PHY 211 – Exam 1

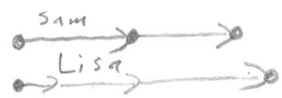
Name (please print): Jack Laiho

SUID: ______________

It is very important that you print your name at the top of every exam page. Please do it before you read any questions!

Document your work. Use the back of each sheet if you run out of space.

1.[25 pts total] Sam is driving at a steady 25 m/s when he passes Lisa, who is sitting in her car at rest. Lisa begins to accelerate at a steady 2.0 m/s^2 at the instant that Sam passes.



a. [7 pts] How far does Lisa drive before passing Sam?

Origin at point where Sam passes Lisa

$$X_L = \cancel{X_{0L}} + \cancel{V_{0L}t} + \tfrac{1}{2}a_L t^2$$

$$X_S = \cancel{X_{0S}} + V_{0S}t + \cancel{\tfrac{1}{2}a_S t^2}$$

$$X_L = X_S \Rightarrow \tfrac{1}{2}a_L t^{\cancel{2}} = V_{0S}\cancel{t} \Rightarrow t = \frac{2V_{0S}}{a_L} \Rightarrow X_S = X_L = \frac{2V_{0S}^2}{a_L}$$

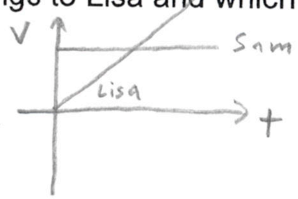
$$X_S = \frac{2(25\,\tfrac{m}{s})^2}{2\,\tfrac{m}{s^2}} = \boxed{625\text{ m}}$$

b. [7 pts] What is her speed as she passes him?

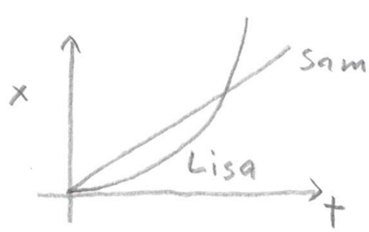
$$V_L^2 = \cancel{V_{0L}^2} + 2a_L X_L \Rightarrow V_L = \sqrt{2a_L X_L} =$$

$$\sqrt{2(2.0\,\tfrac{m}{s^2})625\text{m}} = \boxed{50\,\tfrac{m}{s}}$$

c. [5 pts] Draw the two velocity-time graphs of Lisa and Sam. Your graphs can be sketches, but important features should be labeled. Make sure you label which curve belongs to Lisa and which belongs to Sam.



d. [6 pts] Draw the two position-time graphs of Lisa and Sam. Again, your graphs can be sketches, but important features should be labeled. Make sure you label which curve belongs to Lisa and which belongs to Sam.



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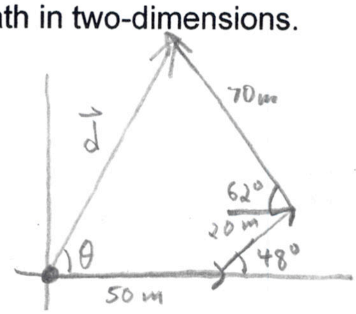
2. [25 pts total] Simon leaves his house and follows the following three step path: He heads 50.0m due east. Then he travels 20.0m at 48^0 north of east. He then travels 70.0m 62^0 north of west.

a. [4 pts] Sketch the graph of Simon's path in two-dimensions.



b. [5 pts] What is Simon's net displacement?

$d_x = 50 + 20\cos 48^\circ - 70\cos 62^\circ = 30.5\text{ m}$

$d_y = 20\sin 48^\circ + 70\sin 62^\circ = 76.7\text{ m}$

$|\vec{d}| = \sqrt{d_x^2 + d_y^2} = \sqrt{30.5^2 + 76.7^2}\text{ m} = \boxed{82.5\text{ m}}$, $\theta = \tan^{-1}\frac{d_y}{d_x} = \boxed{68.3^\circ \text{ North of east}}$

c. [4 pts] What is the total distance that Simon travels?

$50.0\text{m} + 20.0\text{m} + 70.0\text{m} = \boxed{140.0\text{ m}}$

d. [4 pts] Assume that Simon moves at constant speed. If the trip takes 100s, what is Simon's speed?

$V = V_{avg} = \frac{\Delta\text{ dist.}}{\Delta t} = \frac{140.0\text{ m}}{100\text{ s}} = \boxed{1.40\ \frac{m}{s}}$

constant speed, so

e. [4 pts] What is the magnitude of Simon's average velocity?

$|\vec{V}_{avg}| = \frac{|\vec{r}_f - \vec{r}_i|}{\Delta t} = \frac{d}{\Delta t} = \frac{82.5\text{ m}}{100\text{ s}} = \boxed{0.825\ \frac{m}{s}}$

f. [4 pts] What is the magnitude of Simon's average acceleration?

$|\vec{a}_{avg}| = \left|\frac{\vec{V}_f - \vec{V}_i}{\Delta t}\right| = \frac{|(1.40 + 0.657)\hat{\imath} + 1.24\hat{\jmath}|\ \frac{m}{s}}{100\text{ s}}$

$\vec{V}_i = 1.40\ \frac{m}{s}\ \hat{\imath}$, $\vec{V}_f = (\underbrace{1.40\cos 62^\circ}_{0.657}\ \hat{\imath} + \underbrace{1.40\sin 62^\circ}_{1.24}\ \hat{\jmath})\ \frac{m}{s}$

$= \frac{\sqrt{(2.057)^2 + (1.24)^2}}{100}\ \frac{m}{s} = \boxed{0.0240\ \frac{m}{s^2}}$

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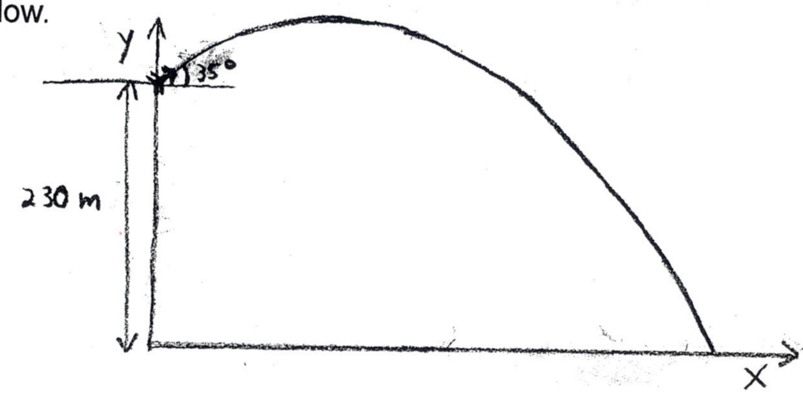
3. [25 pts total] The following diagram shows an arrow being shot off the edge of a very high wall at a speed of 50 m/s and an angle of 35^0 above the horizontal. The wall is 230m above the level ground below.



a. [4 pts] What are the initial (t=0) components of the velocity v_x and v_y of the arrow with respect to the x and y axis shown?

$V_{0x} = V_0 \cos 35° = 50\frac{m}{s} \cos 35° = 41.0 \frac{m}{s}$

$V_{0y} = V_0 \sin 35° = 50\frac{m}{s} \sin 35° = 28.7 \frac{m}{s}$

b. [4 pts] Write down equations showing how these velocity components change with time t.

i. $v_x(t) = V_{0x}$

ii. $v_y(t) = V_{0y} - gt$

c. [4 pts] Write down equations showing how the x and y coordinates of the arrow change with time t.

i. $x(t) = \underbrace{X_0}_{\text{make } 0} + V_{0x} t = V_{0x} t$

ii. $y(t) = y_0 + V_{0y} t - \frac{1}{2} g t^2$

d. [6 pts] Neglecting air resistance, how far in the horizontal direction does the arrow travel?

$y = 0 = y_0 + V_{0y} t - \frac{1}{2} g t^2$ Use quadratic formula:

$t = \dfrac{-V_{0y} \pm \sqrt{V_{0y}^2 + 2 g y_0}}{-g}$ $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

e. [7 pts] What is the magnitude and the direction of the velocity of the arrow when it hits the ground?

$V_x = V_{0x} = 41.0 \frac{m}{s}$

$V_y = V_{0y} - gt = (28.7 - 9.8 \times 10.4)\frac{m}{s} = -73.2 \frac{m}{s}$

$|\vec{v}| = \sqrt{V_x^2 + V_y^2} = \sqrt{41.0^2 + 73.2^2} = \boxed{83.9 \frac{m}{s}}$

$V_{ox} = 41.0\ \frac{m}{s}$, $V_{oy} = 28.7\ \frac{m}{s}$

$\frac{\cancel{m}}{\cancel{s}}\ \frac{s^2}{\cancel{m}}$

3.) d.) cont. $t = \frac{-V_{oy} \pm \sqrt{V_{oy}^2 + 2gy_0}}{-g} = \frac{-28.7 \pm \sqrt{(28.7)^2 + 2(9.8)230}}{-9.8}$

$= 10.4\ s$

$x = V_{ox}t = 41.0\ \frac{m}{s} \times 10.4\ s = \boxed{426\ m}$

3.) e.) cont.

$\tan\theta = \frac{|V_{fy}|}{V_{fx}} \Rightarrow \theta = \tan^{-1}\frac{73.2}{41.0} = 60.7°$

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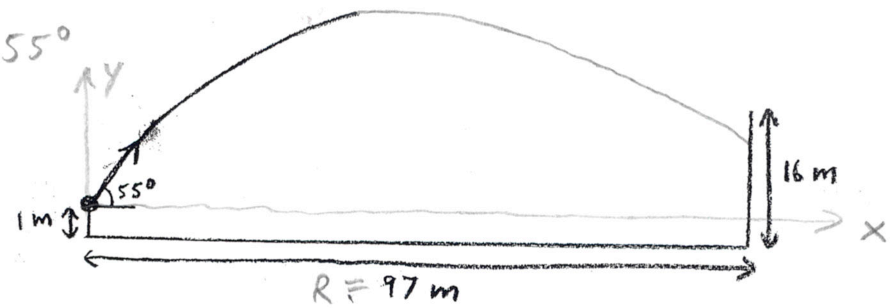
4. [25 pts total] A baseball is hit at a speed of 33 m/s and an angle of 55^0 above the horizontal and 1.0 m above the ground. The backstop wall is 16 m high and 97 m from where the ball is hit. If the ball clears the backstop it is a homerun. Is the hit a homerun? If it is a homerun, by how much does the ball clear the backstop? If not, how far from the top of the backstop does the ball hit?

$V_{oy} = V_o \sin 55^\circ$
$= 33 \frac{m}{s} \sin 55^\circ$
$= 27.0 \frac{m}{s}$

$x =$
$3 \frac{m}{s} \cos 55^\circ$
$= 18.9 \frac{m}{s}$



$$y = y_o + V_{oy} t - \frac{1}{2} g t^2$$

$$x = x_o + V_{ox} t$$

Put origin 1 m above ground. Then

$$y = V_{oy} t - \frac{1}{2} g t^2$$

$x = V_{ox} t$, Let $R = 97\,m$. Then, when $x = R$,

$t = \frac{R}{V_{ox}}$. This is the time the ball is at the same x-coordinate as the backstop.

Then, $y = V_{oy}\left(\frac{R}{V_{ox}}\right) - \frac{1}{2} g \left(\frac{R}{V_{ox}}\right)^2$

$= 27.0\left(\frac{97}{18.9}\right) - \frac{1}{2}(9.8)\left(\frac{97}{18.9}\right)^2 = 9.9\,m$

This is 10.9 m above the ground, or

$16\,m - 10.9\,m = \boxed{5.1\,m \text{ below the top of the backstop.}}$

So the hit is not a homerun.